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The Year 2000 Computer Problem and International Security

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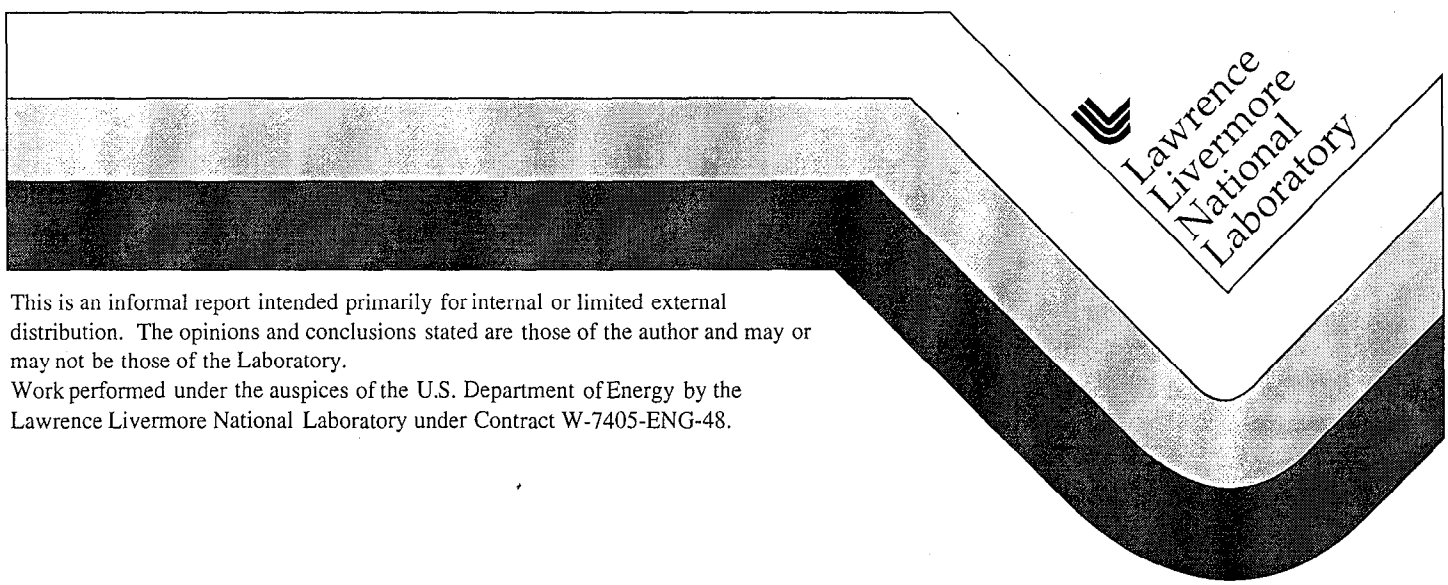

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Introduction

> "The millennium bug is a vivid and powerful reminder of the ways that we are growing ever more interdependent as we rise to the challenges of this new era... The powerful forces of change that have created unimagined abundance also bear within them, as is consistent with human nature, the possibilities of new and unexpected challenges. But if we act properly, we won't look back on this as a headache, sort of the last failed challenge of the 20th century. It will be the first challenge of the 21st century successfully met. That is the American way, and together we can do it."
>
> President Clinton – July 14, 1998

The Year 2000 computer problem (Y2K) is a widespread software issue, that can affect all computers from the tiniest "embedded" microprocessor, to the largest mainframe computer. There are a number of causes of this problem, the most frequent being the use of two digits instead of four to represent the year. As the century digits change from 19 to 20 there is a very real possibility that programs will make errors when processing dates.

This problem is unlike any other that the technical community has faced- there is a fixed deadline for remediating software and hardware, and there is no known way to slip the schedule. This paper discusses the origin of the problem, looks into symptoms and failure modes, describes how organizations are attacking the problem, and then spends some time discussing the international security aspects.

This paper is not meant to be alarmist - however, the author has become convinced that serious consequences are inevitable. The United States, in a national security context, must examine these possible circumstances, and develop an appropriate plan of action.

What is the problem?

There are a number of related problems collectively known as the Year 2000 problem. While computer programmers are accused of causing the problem by using only two digits to represent the year (that is 79 means 1979), in fact mankind has always used this form of abbreviation. Think of the forms and checks that have 19 followed by two pre-printed dashes.

In early days of computing, there were a number of reasons to reduce the length of the year field including saving computer memory, and saving space on 80 column punched cards. And even those programmers with enough foresight to perceive a future problem, did not believe their programs would persist.

When performing date arithmetic, several erroneous results are possible, for example

1999 - 1979 = 20

but

2000 - 1979 = -79 (if century digits are ignored).

Another type of error occurs when records containing date fields are sorted; as the date field rolls over to 00, sorted data will appear in the wrong order. Because people are used to scanning only the newer dates, there is a strong possibility that records will be overlooked.

There are many other dates that can affect system operation - these have been cataloged in a recent paper, "Bad Days for Software" by Capers Jones, in IEEE Spectrum, September 1998.[i]

What are the symptoms?

Computers are essential to modern business; from payroll to accounts receivable and payable, to inventory, to manufacturing and so on, computer systems are the heart of the business. In these applications, dates play a central role. While some problems will be mere nuisances, others can have great impact on business operations. For example, automated purchasing systems look ahead to project when supplies must be ordered. Miscalculating dates would result in either too much, or too little inventory.

Accounts receivable programs compute how many days (or months) a bill is overdue, then send reminders to overdue accounts. Imagine a customer getting a bill that was 100 years over due because of a Year 2000 problem.

Another problem is that computer sort "routines" can get information in the wrong order. For example, e-mail programs put incoming mail at the bottom (or top) of the incoming mail box. Users are accustomed to looking at the bottom (or top) to find new mail. Wrong sorting due to Year 2000 could put mail at the wrong end of the mail box; unknowing users may not see their new mail.

There are many, many other ways that Year 2000 problems can affect operations. Unfortunately, programmers do not have a consistent strategy for dealing with errors. It is entirely possible that a computer system will shut down when it gets a *bad date*. For example, telephone-switching equipment uses redundant computers. Suppose the primary computer sees a bad date, generated by a Year 2000 problem. Redundant computers are usually programmed to switch to their back-up. In this case, the back-up computer would see the same bad date, and would likely shut down the system.

Another failure mode is getting the days wrong. If the computer system sees 00 as the year, and chooses 1900 instead of 2000, the days of the week will be wrong. This could affect systems that change behavior depending on the day of the week.

How bad is the Year 2000 problem?

The Year 2000 computer problem is pervasive, and expensive to fix. The Gartner Group (www.gartner.com) has estimated $600 billion world wide to fix this problem. While this figure is questioned by some, there is little doubt that Year 2000 is a multi billion dollar problem. Businesses who experience failures may be cut off from doing business with some companies. There is a problem of cascading failures; for example, assume that an electric power utility uses control equipment that is date sensitive. Suppose the equipment sees a bad date, and shuts down the utility. Could the failure "cascade" to other power systems, effectively bringing down the grid? Could failure in the power grid, cause the telephone system to cease operation? Or alternately, could loss of telecommunications cause loss of remote control, and thus cause power plants to shut down?

Embedded processors are devices that are buried deep down in equipment. Some experts estimate that 25 billion embedded processors are operating today. Suppose that 0.001% of these have Year 200 problems. If so, then 250,000 embedded processors are at risk. How many of these are in critical applications?

Internationally, many countries are suffering severe economic crisis's. Some experts fear that these countries will not be able to pay attention to the Year 2000 problem. What impact will computer systems in these countries have on business and international relations?

Is Year 2000 a single event?

Year 2000 is not a single event. Per se, Year 2000 is a set of problems, with a set of dates. Because of varying ways computers are programmed, some Year 2000 failures have already been experienced. We expect failures to increase in magnitude, peak near the end of 1999, and slowly taper off.

But, Year 2000 is an example of a more profound problem. Namely, Year 2000 is a sample of a critical infrastructure failure mode. As the United States economy becomes more dependent on computer controlled systems, computer controlled financial transactions, and various kinds of electronic commerce, critical infrastructure failures have the potential of causing many problems. As an example, failure of the Galaxy satellite caused much inconvenience for several days, and yet, Galaxy was a minor problem.

The Global Positioning System (GPS) is used to provide precise navigation to aircraft, ships, trucks, and even private automobiles. Further, the GPS clock is used as a timing reference in some precise timing applications. Not only does GPS have a potential Year 2000 problem, but GPS also has a 20 year rollover problem -- this will occur at midnight on August 21, 1999.

What kinds of systems are affected?

Telecommunications Systems

The Federal Communications Commission (FCC) is responsible for assuring Year 2000 readiness for telecommunications carriers. Extensive discussion with carriers, and review of their web sites indicates little likelihood that *dial tone* will fail. Call set up is independent of date and time affects.

However, there are a number of problems related to telecommunications equipment.

- Supplemental systems such as billing, directory assistance, trouble shooting and maintenance are subject to the date arithmetic problems noted above.
- Voice mail systems often are set up to delete messages that have been on the system longer than a set time. Improper date arithmetic could cause all archived voice mail to be deleted.
- User's passwords on voice mail systems could expire prematurely.
- One manufacturer explained that *call center equipment* (used by large businesses) interconnect with PBX equipment. Due to interconnection protocols used in one model of this equipment, calls would not interconnect if dates are not handled properly by both the call center equipment and the PBX.

Embedded Processors

Embedded processors are ubiquitous microprocessors that are used to control a wide range of devices from microwave ovens to complex factory control systems. [add footnote]. Experts estimate that as many as 25 billion microprocessor chips have been placed in operation. Most of these devices do not keep track of the date, and should not result in a problem. However, there are some micro controllers that are date sensitive. IEEE Spectrum has two excellent articles explaining how these devices operate, and how they might fail.

Identifying and remediating microprocessor controlled systems is a major undertaking. The Los Angeles Times [4] reported that the San Onofre Nuclear Plant was replacing 100's of process controllers that were subject to Year 2000 date change failures.

Mainframe computers

The primary problem with Mainframe computers is the applications software that are the hearts of many businesses. Applications such as payroll, inventory, accounts receivable and payable can be hundreds of thousands of program instructions. There is much date processing, and every line of program "code" must be examined for proper operation. Results of failure due to Year 2000 effects can span the range of minor nuisance to major business disruption.

Unix Systems

Unix Systems (computers using the Unix operating system) are applied in a wide range of business applications. The underlying system clock in most Unix based systems spans the time window of 1970 - to 2038. So the good news is the system clock won't be a problem for 39 more years. However, application software can fail - proper operation is dependent on the date formats used in the system data files.

Personal Computers

Personal computers can be used for a wide variety of applications from home computing, to front ends for large scale computing, to mission critical computing for some businesses. There are two problems of concern: 1) Most personal computers use a device known as a BIOS chip; this chip contains the fundamental microcode for initializing dates. Some early BIOS chips have to be replaced. 2) In addition, applications software has to be upgraded to a version that correctly performs date arithmetic.

What's being done?

Large organizations are attacking the Year 2000 problem in a vigorous manner. Initially, companies were reluctant to share information on what they were doing for potential liability reasons. However, the environment is changing, and many companies and organizations have Year 2000 information on their corporate web sites.

Businesses realize that future revenues are dependent on solving this problem - they have every motivation to remediate their systems and provide as much information as possible. There is a vast amount of information on the World Wide Web. The following sites have useful information, and more importantly, point to many other web sites:

Federal Communications Commission (http://www.fcc.gov/year2000/)

President's Council on Year 2000 Conversion (http://www.y2k.gov/default.htm)

International Telecommunications Union (ITU) (http://www.itu.int/y2k/)

U. S. Federal Government Gateway for Year 2000 Information Directories (http://www.itpolicy.gsa.gov/mks/yr2000/y2khome.htm)

What isn't being done?

There are two major concerns: 1) Smaller businesses will not make necessary changes, potentially leading to severe loss of business, or even business failure, or possibly to cascading effects. 2) That the International Community, particularly those in economic and political crisis, will not remedy the problem

What might happen?

Experts in system analysis suggest analyzing a potential event in turns of its likelihood of occurrence, and the consequences if the failure occurs. Capers Jones, [v] uses experience from the software industry to project failure rates based on efficacy of software defect removal operations. Jones states that defect removal efficiency averages only 85%.

According to Jones

> "with possibly 5% to more than 20% of the year 2000 problems still unrepaired, and remaining in software after the century ends, the probability of significant damages is alarmingly high".

Using the above analysis, Jones assigns probability of occurrence of problems related to Year 2000. His highest (40% of higher probability) projections are bad credit reports, cancellation of year 2000 liability insurance, power outages, and litigation against corporate officers.

My analysis is somewhat different - I project a high probability of problems in the following areas:

> *Just in time manufacturing.* This technique, very popular in this country, minimizes inventory by relying on many suppliers to deliver materials and partial assemblies as they are needed. Imagine a manufacturer who has 100 suppliers, and that each supplier has 10 additional suppliers. If 1/2 of these use computers, what are the chances that 1 out of the 500 involved computer systems will have an error that results in an inventory shortage? What impact will this have on a company, or on the underlying economy?
>
> *Data sorts* There will be a very high number of systems that sort data incorrectly. I suggest that this will cause annoying problems, but that the consequences will be small.
>
> *Embedded processors.* There will be problems with embedded processors. The real issue is whether or not these will be severe problems. I estimate that there will be some severe problems, but nothing on a nation wide basis. (That is, the effects will be isolated).
>
> *International communications.* Present data suggests that many countries are lagging behind the United States in Year 2000 remediation efforts. An ITU survey states that the large fraction of countries have already certified that their telecommunication systems will operate. Even if this is correct, there has been nothing said about data communications. The probability is that there will be severe problems with data formats between countries. (This is because date formats have to be expanded to four century digits). This will cause a severe problem if some systems cannot interact.

International Implications

Many writers have speculated on the failure of embedded processor systems. For example, Mark Frautschi [vi] writes that assessment, repair, and testing of a medium size non nuclear plant will cost 30 - 40 million dollars and take almost two years. Computer systems researchers worry about the behavior of nuclear, chemical, and biological plants, and weapon systems as the Year 2000 approaches.

Los Alamos National Lab (http://www.lanl.gov/projects/ia/year2000/) states that:

- Alarm systems might miscalculate the day of the week (thinking it's 1900 instead of 2000), leading to shut downs or false alarms.
- Software can shut down, thinking that its license has expired. Monitoring equipment can hang while it waits for a year greater than "99".

Both of these could have severe international consequences if the failed equipment were located in a chemical or nuclear plant.

In a Miami Herald Article [vii], Alexander Krupov, chairman of Russia's Central Telecommunications Commission said "Compared with other countries, I must say we are behind." In the same article Vladislav Petrov, spokesman for the Atomic Energy Ministry, said that "we're going to deal with the problem when we get to the Year 2000."

I have already noted the problem of data communications between countries. There has been some talk that businesses may not interact with businesses in other countries if they don't successfully address their Year 2000 problems. Such an event would clearly lead to severe international consequences.

Conclusion

We have looked at the source of Year 2000 problems, possible symptoms, risks and consequences from failure. There can be no doubt that Year 2000 computer problems will lead to isolated failures. While a nationwide catastrophe is unlikely, transactions between international partners may be at risk.

Further, there is a remote possibility that embedded processors will cause a major incident at a chemical refinery or manufacturing plant. Many organizations are continuing to work hard on increasing dialog, distributing lessons learned, and preparing for failure. We must continue to be as diligent as possible.

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[i] Capers Jones, "Bad Days for Software" IEEE Spectrum, September 1998.
[ii] Richard Comerford and Tekla Perry, "Brooding on the Year 2000", IEEE Spectrum, June 1998.
[iii] Dick Lefkon and Bill Payne, "Making Embedded Systems Year 2000 Compliant", IEEE Spectrum, June 1998.
[iv] Los Angeles Times, August 3, 1998
[v] Capers Jones, "Probabilities of Year 2000 Damages", www.year2000.com/archive/proby2k.html
[vi] Mark A. Frautschi, "Embedded Processors and the Year 2000 Problem", http://www.tmn.com/~y2k2.html.
[vii] Miami Herald, September 16, 1998

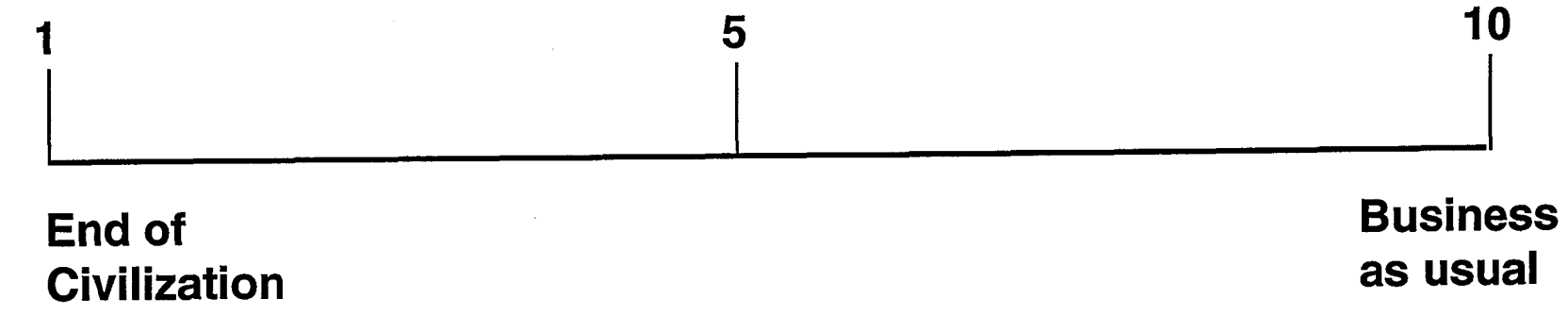
The Year 2000 Problem and International Security

A System Engineer's View

Stan Trost

October 13, 1998

Let's take a poll



Some quotations:

- "Prepare for the worst. Hope for the best." - Ed Yardeni
- "The Federal Reserve System is probably going to be okay. But our systems are integrated with the rest of the world .. Even though major banks and countries are moving at fairly rapid pace, we don't know and may not know until the actual time arises ...
- The millennium computer bug is totally predictable in its timing, but completely unpredictable in its effects. Its greatest danger, writes Frances Cairncross, lies in that uncertainty.

The Challenge: Assure minimum disruption to the telecommunications infrastructure through the year 2000 transition.

Current State Assessment:

- Large organizations have generally accepted five stage model (inventory, assess, remediate, unit test, integration testing, and implementation.)
- Many of these organizations are well along in third stage.
- There is considerable concern regarding readiness of smaller organizations.
- Internationally, there appears to be less than ideal readiness.
- The United States telecommunications industry (large organizations), are beginning integration testing on controlled test beds.

A case history, Galaxy IV

- Galaxy IV failed on May 19th, 1998
- 40 million pagers affected
- Police, fire, doctors could not be paged
- Pharmacies could not fill prescriptions - insurance companies could not authorize payments
- Gas stations and other retail could not accept charges

Companies with contingency plans were able to recover, consistent with their own plans. Others had to wait.

Understanding the problem

- **Y2K is not a single event**
  - ***Problems have already occurred. Expect problems to peak in late 1999, early 2000, and then slowly taper off.***
- **Dates are everywhere, in many different formats. And programmers (bless their hearts) are inconsistent about error handling techniques.**
- ***There is no silver bullet***
- **There are many, many manifestations of problem.**
  - ***GPS problems, including GPS used as timing source***
  - ***Embedded processor problems***
  - ***Real time systems including remote utility control***
  - ***Date arithmetic in financial and business programs***
  - ***Premature expiration (Licenses, credit cards, passwords)***

What might go wrong

- Loss of electric power
- Loss of telecommunication
- Problems with electronic financial transactions
- Embedded processor problem
- GPS systems
- Just in time manufacturing

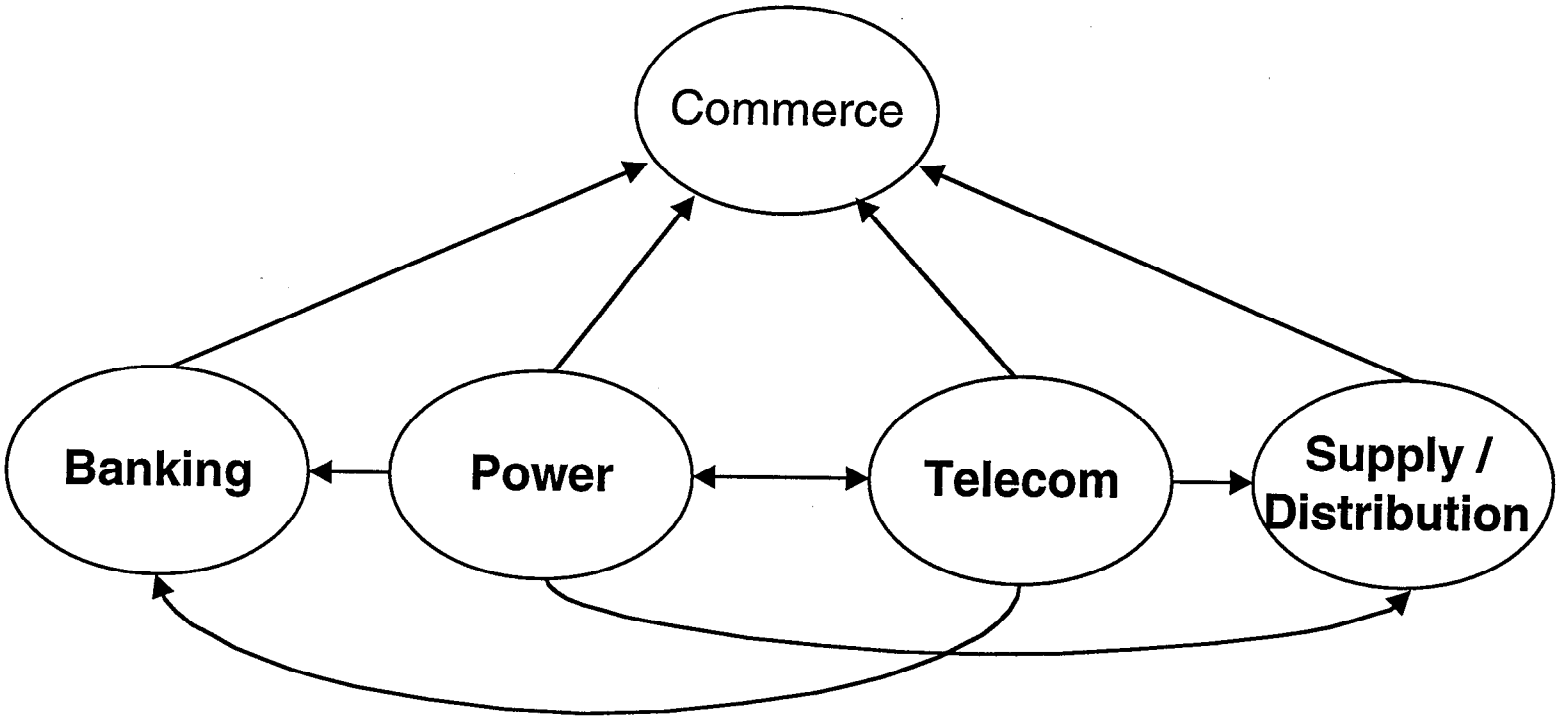
Fixing Y2K is like eating an elephant - do it one bite at a time

- Must apply the 80-20 rule
  - *20% of systems affect 80% of communications*
- Focus on essential emergency, military, and commercial communications.
- Have to look at highest leverage situations
  - *Assuring major IXC's can operate*
  - *Emergency communication in largest counties*
  - *Broadcast networks*

Just in time manufacturing illustrates the problem

- Assume an auto manufacturer runs a "JIT" plant
- Assume there are 100 suppliers
- Assume each supplier has 5 additional suppliers
- What's the likelihood of delay due to Year 2000 purchase order problems?
- What are the consequences?

Understanding dependencies is critical to success



Focus on the United States: What are the concerns?

- Getting smaller entities to attain minimum state of readiness.
- Assuring that emergency services will work.
- Being sure that United States companies and organizations prepare and can execute appropriate contingency plans.
- Being sure that business communications have minimal disruption.
  - *Must pay attention to electronic commerce, just in time manufacturing, and financial transactions.*
- Assuring that critical embedded processors are located and repaired.

There is less than fifteen months to century date change

What are the International concerns?

- There appears to be far less effort being made to solve problem.
- Economic crisis in Asia affects resources available for Year 2000 fixes.
- Introduction of the Euro is a major computer event, competing for computer programmer resources.
- ITU reports communication readiness in many countries, but is this believable?
- Could Year 2000 induce problems in manufacturing plants?

> "We are going to deal with the problem when we get to the Year 2000". V Petrov, Atomic Energy Ministry

International concerns - continued

- Will "compliant" countries cut off those that do not attack problem?
- Will embedded processors cause serious problems?
- Is combination of Euro and Y2K beyond digestion?
- Will Y2K worsen global economic situation?
  - see www.yardeni.com
- Are there defense related problems?

Developing an effective communication, outreach, and demonstration program is essential for success. This plan requires several elements:

- Recognition that there is very little time.
- Leverage the big players, rather than regulate them.
- Get as much information to smaller organizations as possible.
- Plan and complete series of successful tests.
- Work the high priority sectors in parallel.

Public needs to understand this is a major national program, unlike any that have preceded it.

- We had time to enter the "great wars" - and they were fought on non- US soil.
- The Apollo mission, while high risk and ambitious, did not have to stay on schedule.
- The date will not slip - minimizing affects can only be done through unprecedented cooperation of government, industry, and the public.
- Not only do we have to solve the US problem, but we have to help minimize international problems.
- There is direct analogy with the AIDS epidemic, but abstinence will not halt the spread.